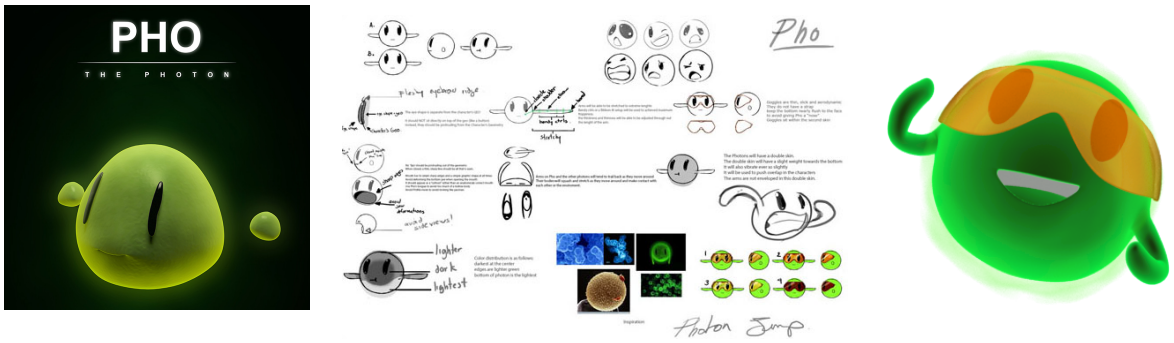
Collaborative Computer Graphics Product Development between Academia and Government: A Dynamic Model

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(a) *(b)* *(c)*

Figure 1*: (a) Character Pho the Photon at the end of the Pilot Phase, (b) Refinement of Pho and the development of style sheet during the visit at NASA/GSFC, (c) Pho the Photon at the end of the Production Phase.*

Abstract

Collaborations and partnerships between academia and government agencies are common, especially when it comes to research and development in the fields of science, engineering and technology. However, collaboration between a government agency and an art school is rather atypical. This paper presents the Collaborative Student Project, which aims to explore the following challenge: The ideation, development and realization of education and public outreach products for NASA's upcoming ICESat-2 mission in collaboration with art students.

Keywords: academia industry/government collaboration, art science collaboration, computer graphics product development, product development with students, applied arts, media arts

Concepts: • **Applied computing ~ Education** • **Social and professional topics ~ Model curricula** • Social and professional topics ~ Computing education • **Applied computing ~ Collaborative learning** • **Applied computing ~ Media arts**

1 Introduction

In Spring 2013, NASA's Ice, Cloud and Land Elevation Satellite-2 (ICESat-2) mission approached one of the authors[1] to explore the development of new types of educational and public outreach media with three goals in mind: a) educate, inform and engage the public in NASA's ICESat-2 mission, in a fresh and visually engaging way; b) conceptualize and develop products to appeal to the non-science aware public; and c) augment the existing in-house capabilities and explore new ground.

To address this challenge a bifurcated approach was put in place: on the one hand, work with students from the applied arts to tap into creative talent that has an understanding and know-how of visual craftsmanship; and on the other, set up and launch a pilot project with an art school and establish a structure for the ideation process and a separate one for product development. If the pilot results were successful, students of select concepts would work with in-house experts to transform their ideas into real products.

This endeavor could potentially serve as an educational program for both the art school and the agency. Art students would not only participate in a real project for a NASA mission, but would also gain insight about the goals, science and state-of-the-art engineering and technology behind it. In addition, students would see their ideas realized from concept to a live product while working alongside experts in product development, and interface with a wide variety of professionals including scientists, engineers, educators and digital media experts. While participating in such an effort, students would gain exposure to job prospects and possibly be hired at NASA. As a result, NASA would bring new talent and nurture collaboration between: i) government and an art school, ii) art students from various disciplines while focusing on highlighting the unique skill sets of each one, and iii) art students and professional experts while guiding them through the entire life cycle of a project. The benefits for both the students and the mission seemed promising and in late 2013 the Collaborative Student Project was launched. In early 2014 Savannah College of Art and Design (SCAD) joined this effort. Within a few months a custom SCAD Collaborative Learning Center course was designed jointly with the mission. It was the first time either side participated in a similar effort and it was clear that careful planning, selection of team members and product management would play a critical role to this project.

In the following sections we provide a brief overview of relevant

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models, and then we describe the pilot project, the development of select products with students and the development of spin off projects. We conclude with the outcomes and our observations.



Figure 2: *Kick-off meeting of the Pilot Phase at the SCAD Savannah campus. Project Scientist gives an overview of the mission to the Savannah team and the Atlanta team (attends virtually)*

1.1 Background

Collaborations and partnerships between universities, industry and government showed signs of growth immediately after World War II and by the 1970s were propelled by technological innovation and social transformations in academia [Lievana 2010]. Between these periods (i.e. in the 1950s) is when the concept of "research and creation" emerged as university faculties saw increased value in their research output. Around the same time the first art programs in the US were integrated in university curricula and art departments were established as part of academic institutions. The role of artists started to transform in these academic settings and evolved from artist-creator to artist-teacher, artist-researcher, and artist-entrepreneur [Fourmentraux 2007]. Artists always held such roles, but with the development of academic art programs new formalized communities of practice emerged, particularly when progressively more artists participated in collaborative interdisciplinary research.

Developing structures for partnerships that bridge the university-industry/government divide while respecting their disparities and producing seamless interactions between them, is an important but complex subject. Literature shows that the research of these topics and the dissemination of lessons from such models [Edmondson et al. 2012; Jones and Clulow 2012] along with the success factors [Wohlin et al. 2012] and benefits for both sides are concentrated in the areas of engineering, health, and information sciences. This is not surprising since the stakes for economic growth and innovation are high in these areas.

All this begs the question: how do these models and observations translate to collaborations between industry/government and academic programs in design, new media and applied arts? The animation, game, and entertainment industries along with the recently popular fields of visualization, virtual reality, and design thinking should be looking for such partnerships. Large corporations and animation studios have been fostering such relationships, but what about smaller companies, government agencies and non-profits? Even large companies that develop partnerships with art schools usually collaborate with faculty and students either in the design/ideation phase of a project, or within a specific duration (summer semester, year long project) to address a concrete set of problems and tasks, but do not extend to the entire production development process (from conception to final phase). These are challenging problems to solve, and they become even more so when interdisciplinarity is involved.

1.2 Relevant Models

The positive effects of academia-industry/government partnerships in the field of arts as it pertains to design, computer graphics and interactive techniques is mirrored in the growth of three main platforms that enable such initiatives: a) collaborative academic centers, b) specialized academic courses and projects, and c) internship opportunities.

Such collaborative **centers** are housed in universities and specialize in developing partnerships with clients. These centers enable such partnerships by providing administrative support, infrastructure and the know-how in working on such initiatives. For example, the Collaborative Learning Center (CLC) at SCAD creates customized partnerships with businesses and organizations to generate design-based concepts for experiences, products, media and technology. These partnerships can take place at any of the SCAD locations, by recruiting student talent among 40 disciplines and can have the form of a design challenge or of a custom course. The Innovation Center at the University of Illinois at Chicago serves as an incubation, education and collaboration center that initiates programs bridging research and education with industry. The programs bring together students, companies, experts and educators to collaborate on real world problems and deliver results. The center houses the Interdisciplinary Product Development (IPD) program, which has developed a two-semester curriculum that combines Industrial Design, Mechanical Engineering and MBA/Marketing students. A corporate sponsor works with faculty from the three colleges and together they provide a challenging assignment to the students.

Undergraduate or graduate programs offer specialized **courses** (usually one or two) or the opportunity of a **capstone project** that facilitate interaction with industry/government professionals and match students with real world projects. A successful example is the summer industry course offered at the Department of Visualization at Texas A&M [Anonymous 2011]. This industry course provides students with real-world experience from a computer graphics studio, such as Disney and DreamWorks. Students are assigned projects from professionals in the animation industry and receive feedback and guidance from them and the professor who runs and manages the course. The Entertainment Technology Center (ETC) has been putting together 15-week graduate courses sponsored by a client focusing on media and entertainment technology issues related to the client's business. Other notable programs that offer similar opportunities to students are the Innovation Space at Arizona State University and the undergraduate Collaborative Innovation minor by the Department of Art, Art History and Design at the University of Notre Dame. NASA has served as a client in the Master's of Human Computer Interaction Capstone Project, offered at Carnegie Mellon. In this 32-week graduate curriculum students design, develop and test a prototype of an improved, modified or existing human-to-machine technology. A significant partnership between an art school and NASA is the collaboration between the Astrophysics division at

NASA/GSFC and the Maryland Institute College of Art (MICA). In Spring 2015 animation students from MICA collaborated with NASA astrophysicists on a 5-week course to translate science concepts into animations. The outcomes were five short animated films that explore dark matter, binary stars, Fermi bubbles and space debris [MICA 2014] and a summer (2015) internship offered to one of the participating students.

Internship opportunities, in order to be successful for both sides, require developed partnerships between the institutions and support from faculty. The most common type of internships are the ones that take place during summer (approximate duration 8 weeks), but organizations along with academic institutions support ones with longer duration up to a year. Often times, successful efforts from students during specialized academic courses and projects (mentioned above) may lead to internship opportunities and in some cases even full-time employment.

Even though the three main platforms described above facilitate participation of students in real-world projects, at the same time they limit student involvement to the ideation/pilot phase or prototype development. Since these existing platforms would not be sufficient for the project described in this paper, a new type of platform was set up to serve the students, the art school, and also the mission goals. As far as we know, realization and development of products with design, and digital/applied arts students as the main workforce is an atypical scenario.

1.3 Motivation

NASA's Science Storytelling Team serves the agency by developing, releasing and disseminating media products and news packages across a variety of platforms. These products aim to: a) support scientists in their outbound communication efforts, and b) inform and educate the public about the agency's latest research and mission results. These activities are coordinated closely with scientists, technologists, science visualizers, conceptual animators, producers, science writers, social media experts and education and public outreach specialists. Descriptions and reflections on the teams, workflows and the types of media produced have been included in [Ma et al. 2012; Kostis and Cohen 2012]. One of NASA's outreach efforts is to reach out to a larger audience and inform and educate the public about its mission, research efforts and science results. The Science Storytelling Team aims to address all these aspects and is a successful example of a rather unique science-media production group in the government ecosystem. The Science Storytelling Team, like most NASA programs, groups and missions, supports internships, fellowships and related programs, like the Pathways. This wide variety of opportunities naturally follows a specific set of guidelines, rules and timelines.

The Collaborative Student Project aimed to explore the problem-space by trying to answer the following questions:

a) How can one engage new, previously-unreached audiences, and especially the non-science aware public?
b) How can one extend ongoing media and public outreach efforts and try out new directions in a pilot phase for the development of products with a new look and feel?
c) How can one tap in the arts and the creative talent for the development of such ideas and products, especially since they can offer value both by visually engaging content creation and by providing a different perspective to outsiders?
d) What would make such an effort unique, engaging, and, most importantly, meaningful and educational?

The problem-space was addressed by putting together a pilot project with the following characteristics:

- Engage students who are trained and skilled in visual traditions.
- Involve students from a wide variety of applied art disciplines.
- Offer a blank canvas to the students ready to be filled with a new set of ideas and no limitations.
- Involve art students from the ideation to the realization phase and develop ideas in tandem so that they participate in the entire creative process.
- Empower students with support and guidance.
- Respect and stay true to their initial concepts, while providing feedback and guidance for refinement.

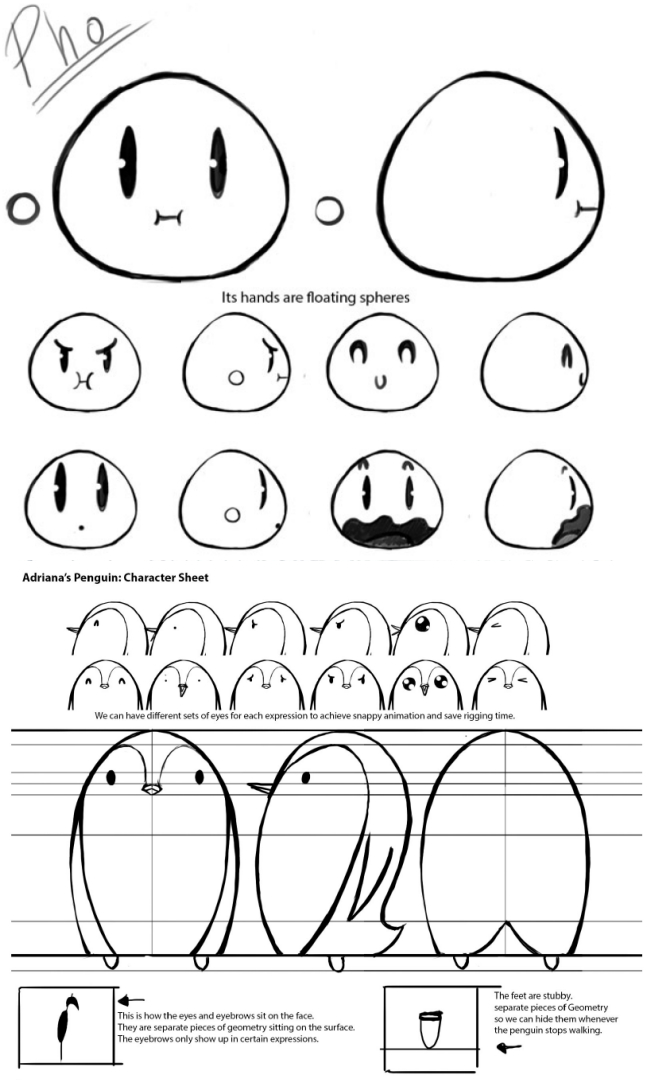


Figure 3: *Character style sheets for Pho the Photon and Paige the Penguin developed by students during the Pilot Phase.*

2 Student Collaborative Process

The student collaboration began as a pilot project in the form of a SCAD CLC class involving 24 students, 16 in Savannah and 8 in Atlanta. The collaboration continued in the form of internships taking place in Savannah and involved the implementation of concepts selected from the pilot phase. This second phase consisted of a core group of 13 students. The collaboration continues and to-date this partnership has created 22 individual internship opportunities (as of May 2016) as well as the hire of one SCAD alumna at NASA's Conceptual Image Laboratory located at Goddard Space Flight Center.

Each phase was distinct in goals, structure and required skills. This required differing methodologies as well as distinct talents and skill sets. The first methodology was analogous to a computer model simulation for idea generation, with an initial state (client specification), a process of selection (client feedback), and guided refinement (client and professor supervision) to the final goal. The second methodology brought the animation studio pipeline into the classroom. After these two phases, the collaboration with SCAD continued with smaller teams on more specific tasks. Interest in the project from other groups at NASA GSFC resulted in products spun off from the collaboration.

This discussion will focus on the process of both phases implemented at the Savannah campus.



Figure 4: *Group photo at the end of the Pilot Phase, during the Final Presentation day at SCAD Savannah*

2.1 Pilot (Phase1: CLC)

The pilot phase of the project was a CLC Custom Course. This type of project runs for the duration of one quarter (10 weeks) and typically involves students from multiple disciplines, supervising professors and a client. It begins with an initial kick-off meeting with a client introduction (Figure 2) and later, at midterm and final weeks, the students are required to present their designs to the client. Both events require polished presentations and, at the final event, a printed bound book summarizing the process and its outcomes.

Student team members were selected through an interview process with the supervising professor. The role of the professor in this stage was that of a recruiting manager seeking talent that matched the desired skill sets, showed interest in the project, was enthusiastic about their work and showed experience or potential for being able to work in teams.

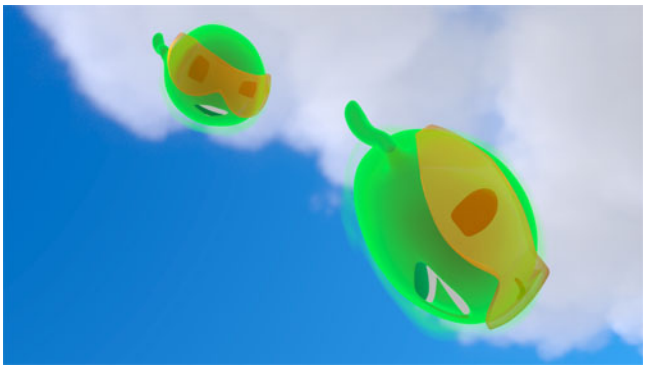


Figure 5: *Still frame from the animated short Photon Jump*

During the course of 10 weeks, students proposed concepts that were selected and refined under the guidance of supervising professors (Professor Fowler in Savannah and Professor Stallworth in Atlanta) within the CLC program. Team meetings were held 2-3 times a week with a weekly check-in with the client/Product Manager Helen-Nicole Kostis, as well as less frequent feedback from other external members including Project Scientist Dr. Thorsten Markus and EPO Coordinator Valerie Casasanto.

The role of the Product Manager was to represent the mission in this project, communicate project goals, provide feedback to students and supervising professors, and help guide the students through an iterative process toward a desired result. The role of the supervising professor was similar but at a level of more day-to-day operations, including activity management as well as selection of students and task assignment.

As is characteristic in a CLC class, and as requested by the client, a variety of student majors were purposefully chosen. This provided a cross section of digital media students with diverse backgrounds among team members, both undergraduate and graduate. Majors represented were visual effects, animation, motion media, and sequential art. Participating students originated from across the US as well as from China, Indonesia, India, Mongolia, Mexico, Turkey, Vietnam, NW Africa and Canada. This diversity provided a broad spectrum of viewpoints and skill sets, enriching the team as well as increasing the probability of successfully creating concepts that appeal to a larger demographic.

After team selection prior to the start of quarter, the students were introduced during Week One to the ICESat-2 Project Scientist, Product Manager and members of the Educational Public Outreach (EPO) team. An important element of the collaborative process is for students to understand both the goals of their assignment as well as NASA's ICESat-2's mission as a whole. ICESat-2 will measure the height of Earth with state-of-the-art laser pulse technology – 10,000 laser pulses a second, giving scientists unprecedented detailed data about our changing planet. The Project Scientist visited the Savannah campus to introduce the SCAD team to the mission and explain the science and engineering behind it. Team members from the Atlanta campus attended via teleconference. The following week, the Product Manager provided an overview of NASA's EPO efforts, teams and products, outlined the goals of the Collaborative Student Project, the educational goals of the mission and the expected outcomes of the project. Relevant research papers highlighting the

mission efforts were also provided, along with reference links to media products and press releases.

With these guidelines, students were then given a blank canvas and were asked not to restrict their thinking to what the typical NASA audience would like, but consider the atypical viewer and bring new audiences that may not usually explore this domain. Frequent feedback (biweekly and weekly) was necessary to refine concepts while at the same time respecting creative freedom.

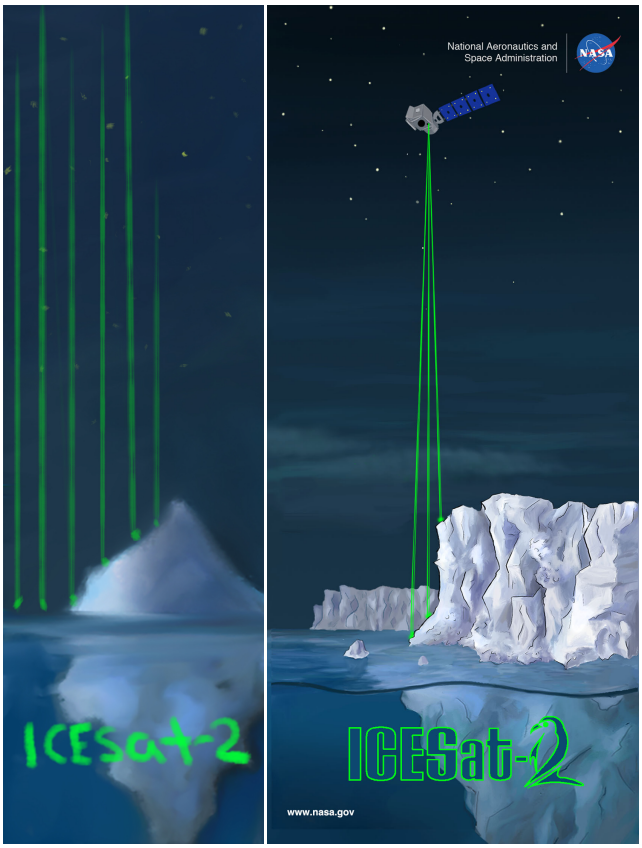


Figure 6: *Lenticular bookmark design at the end of the Pilot Phase (left) and the realized ICESat-2 lenticular bookmark developed at the end of the Production Phase.*

An initial selection of team leadership roles for students was made by the supervising professor. Later, sub-teams would be formed and within the sub-teams, students developed leadership roles within those groups; for example, one person was nominated to present for each sub-team during formal events. As implemented in CLC class projects, more formal leadership roles included financial, delivery (in our case electronic files), event and process book leads.

The class structure was defined with 2.5 hour bi-weekly meetings (SCAD standard class duration) as well as occasional weekend meetings held in anticipation of presentations to the client. This structure allowed the students to continue their other regularly scheduled classes while participating in the project. This particular phase of the project required a balance between structure and the ability to dynamically change members' roles or change directions. As concepts were presented and selected, team topics and team members were redistributed. The professor's role was to oversee team dynamics and plan class activities, which were subject to change as the need arose. The client played a crucial role in refinement with frequent feedback (weekly) and extensive notes. The professor's role was to ensure focus and help students analyze and apply this feedback, adding suggestions for direction to steer the team toward the next weeks' goals.

During the first week, after introductions, students participated in brainstorming sessions to rapidly generate initial categories, ideas and concepts. The process was dynamic, starting with whole-group sessions and then breaking into smaller teams. The 16 person team in Savannah was split into smaller teams (4 in total) based on potential ideas. These categories were outlined by the students and were related to the client presentation and the project's subject matter. From this initial brainstorming session during Week One, the students had to propose, critique, refine, and select concepts to present to the team and then reshuffle the teams based on the idea that interested them the most. Each idea was required to have a description, a mood or reference board (a collage of images that referred either to the style or the story) and pre-visualizations if possible.

In Week Two they were to take these materials and produce a storyboard to further detail their ideas. As the goal was to have a wide variety of proposals, and research needed to take place as well, teams were dynamic and varying roles were assigned. This fluid structure allowed full utilization of the pool of talent as there may be overlap in skills as well as changes in interest. So a 5/5/3/3 split one week would become a 3/3/3/2/5 for example. These team numbers were also dynamic as there was sometimes overlap in ideas.

Along with dynamic team numbers and continually refined projects came charts and schedules which were kept on a class-accessible website with an eye always toward the next client presentation. Weekend meetings before the formal midterm meeting were used to practice and polish a refined presentation of the ideas which spanned website design, apps, stories and products. Seven presenters were selected by their various teams to present proposed ideas.

The midterm meeting was held in Atlanta during Week Six, with both teams and the Product Manager attending in person, while other ICESat-2 team members attended via video conferencing. After the formal presentation, each idea was given very specific and detailed feedback from the client in a follow-up document. Although the feedback was on the whole positive, the ideas needed more punch—the goal was to seek innovative ideas with stronger impact. Identifying exactly what might appeal strongly to a client and hitting on the indefinable something that a client will become enthusiastic about is a difficult and common goal in many industries. The students needed to analyze and extend this information, given both in person and written form.

It was important at this point to guide the students to carefully analyze the critique and focus on the why of what worked and what did not. This is where the ability to change directions quickly became crucial. Rather than focus on the documented ideas and simply follow through with these, the supervising professor challenged the students to come up with new ideas. Although this involved risk, this tactic had a definite pay off. The students were assigned the task during class period to discuss the wackiest story ideas based on the feedback that, given their five weeks of research and insight into understanding the client and the project, would potentially impress them. These new-found insights produced ideas that were closer to the client's needs.

These were presented in Week Seven and the positive reception sparked energy in the team and newfound enthusiasm led to new stories, character designs, posters and excitement for the final presentation (Figure 4).

The role of the supervisors, both internal and external, was to provide guidance and encouragement while keeping the team on schedule as well as allowing as much freedom to create ideas as practical. This often required careful analysis of the process and the ability to change directions quickly. Both internal and external supervision was extensive. One of the project's intentions was to nurture that analytical skill and encourage initiative in the students.

This first phase resulted in concepts for stories, game apps, posters, bookmarks, character designs, museum installations, social media assets and an ICESat-2 website redesign. After the final presentation and discussion by the ICESat-2 team, the client selected concepts to be developed for a subsequent phase. From this initial pilot project, we continued the collaboration to the next phase, extending the CLC concepts to multiple projects. This first phase was highly successful as illustrated by the high level of productivity as well as further concept development indicating client satisfaction.

2.2 Implementation in the guise of Production

Several concepts were selected by the client to be further refined in the next phase: an animation short titled *Photon Jump* (Figure 5), two characters (Figure 3), various EPO hard copy materials (posters, bookmark in Figures 9 & 6) and the redesign of the ICESat-2 website. The primary focus of the second phase was on *Photon Jump,* prototyping of the website design and refinement of the two character designs selected as mascots for ICESat-2, *Paige* and *Pho* (Figures 1, 3 & 8). The discussion following will focus mainly on the process for the animation production, *Photon Jump*.

The implementation phase spanned an approximately 15-week period while a SCAD quarter spans only 10 weeks. There were two reasons for this decision: to allow further refinement of the concepts selected and to have access to render resources that were more readily available after end of quarter.

This phase was very different from the pilot phase, and involved modeling the class as a production. As part of this structure, a typical animation studio pipeline was employed. During the implementation, student tasks were very specific and guided, in contrast to the pilot phase. This phase was conducted in the form of internships that were supervised on-site at SCAD Savannah. Team selection and student roles were based on the tasks required, skill sets related to specialization and participation in the pilot phase. Continuity and familiarity with the overall project was beneficial and 6 students were selected from the pilot phase. In total, 13 students contributed during this phase, however not all at once. This is similar to studio employment during production.

The structure of the work had three main components: further refinement, regular production, and final-phase production. Feedback for the refinement phase was daily, for regular production, daily and weekly, and continuous for final phase production (sometimes in the industry referred to as crunch time). Each component also encountered its own unique challenges, as discussed in Section 3 (Outcomes).

For further refinement, it was important to bring core team members from SCAD to NASA/GSFC to work together on site for multiple reasons: to expedite the refinement process by working intensively face to face with the Product Manager, to introduce the mission at a more personal in-depth level by meeting ICESat-2 engineers and scientists, and as an opportunity for select students to visit NASA GSFC in person. This occurred a week before the SCAD quarter started.

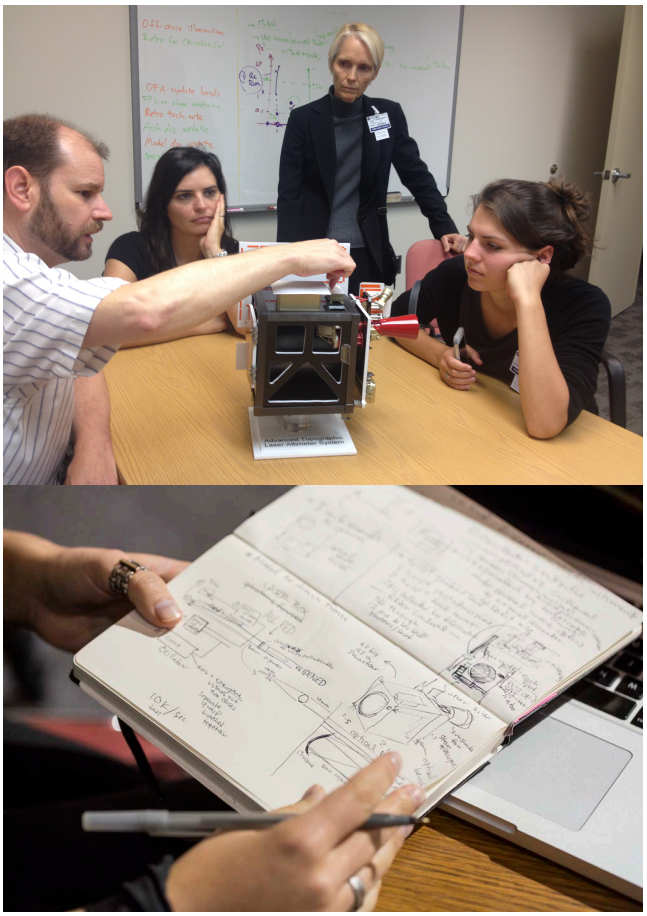


Figure 7: *ICESat-2 engineer explaining the optics of the ATLAS instrument onboard the mission on a model (top). Sketches from team member Kristina Ness of the mechanics of the ATLAS instrument (bottom).*

The goals of the visit were to refine storyboards for *Photon Jump,* improve character design (Figures 1, 3 & 8) and define look development specifications to move forward to production. In addition, the ICESat-2 website structure and content was mapped out as well as ideation for posters. An educational benefit for the students attending was an increased understanding of NASA's ICESat-2 satellite technology and mission goals (Figure 7).

The production employed a typical studio pipeline which includes modeling, rigging, sequence and shot breakdown, layout, look development, animation, lighting, rendering and compositing. This is a simplification and in industry rarely does this process follow a linear path but rather loops back to iterate on a needed task and can become intertwined. This was consistent with the experience in this production, giving students from the various majors a look at aspects of production other than just their chosen specialization.

A timeline of the various aspects of production was laid out. Many production tasks rely heavily on previous tasks being completed; a delay in one can create a domino effect down the pipeline. Logistics for non-ideal scenarios had to be planned to use student time effectively. For example, sphere proxies and then preliminary unrigged models of *Pho* were used for shading and rendering tests.



Figure 8: *Characters Pho the Photon and Paige the Penguin after the Production Phase. Both characters serve as mascots for ICESat-2 mission.*

Delays must also be quickly recognized, schedules adjusted and tasks re-assigned to optimize resources. For example, *Pho*'s rig took longer than anticipated to complete which would have an impact on animation and ultimately rendering and shot completion. Shots may be delayed from proceeding through the pipeline but time can be spent effectively if resources can be re-assigned. All of the tasks required in production must be organized and tracked, and delays of individual phases impact on others anticipated.

The roles of the supervising professor and client changed with this phase of the project. The roles for Deborah Fowler were of recruiter, educator, production manager, supervisor, organizer, and trouble shooter on *Photon Jump* while overseeing the day-to-day operations, not unlike the previous project. The roles for Helen-Nicole Kostis were of producer, coordinator, product and project manager, making sure the dialogue between both sides was clear, feedback was provided on time, and the project was meeting the goals of the mission. In addition, Helen-Nicole Kostis handled the immediate supervision of the website design and of the bookmark project.

The production team was selected with specific tasks and roles in mind. For *Photon Jump*, these were broken down into story and concept (pre-production), production, and sound design (post-production).
Understanding the challenges of production at a very detailed level was an important experience for the students. Student roles varied with the refinement phase and during production as well as some team members participating in multiple projects. In addition, similar to a small studio production, students were required to work both on tasks they were familiar with and some less familiar as the need arose. This allowed students to experience the professional requirement for adaptability.

The supervising professor oversaw production management, charting milestones and deadlines [Fowler 2014] for the various tasks of *Photon Jump* and assigned student responsibilities accordingly. It was crucial for success that students ensured their portion of the production was on time and deadlines were met. Students were given leadership roles such as animating supervisor, sequence leads, pipeline lead and so on.

Photon Jump was divided into three sequences based on environment location: exit, outside, entry. A list was compiled of software versions, and per sequence assets, tasks and effects that would potentially be required such as character model including rigging, environments, clouds and crowd effects. In order to keep track of progress, a process of dailies with supervisor and client were held similarly to the pilot phase. In addition, the supervisor mapped out a master timeline [Fowler and Kostis 2014] and the project deadlines were set.

Organization, file management, and shot tracking are necessary in a successful production. The pipeline Technical Director (TD) along with other key members who had experience in collaborative projects were assigned the tasks of drafting proper naming conventions for file organization. Additionally, for shot tracking in a studio, production software (commercial or proprietary) is often employed. Without access to this type of software at the time, an extensive Google sheet was designed to record shot list events that team members had access to and were required to update. Animation created an additional chart for tracking start and end dates of shots. Both of these charts were utilized so students would quickly see the impact of slipping deadlines.

A useful practice is to have a continuously refined edit of the story—a storyboard incrementally transformed into the final rendered animation—this protocol was followed throughout the project. As the production progresses, storyboards are replaced with playblasts, then preliminary renders including animation, lighting and gradually the edit is refined to the final result.

Since the story was still being refined during the beginning weeks of production, the team focused on creating environments and models. Model packets were created and the modeling and rigging process started soon after. Testing of the character's movement, expression and look development needed to be completed to finalize the character definition. Since our character, *Pho*, was relatively simple, proxy geometry could be used to test shaders and other effects. This was similar to a mini-pre-production phase (preliminary tests performed before production starts in full) and occurred at the same time story was being polished.

By Week Three, many of the assets were built and layout could begin as the story was getting closer to being locked. The storyboards were compiled into an animatic, or what is sometimes called a pre-vis. The story was still to undergo a few changes after review by client and internal members but was largely considered locked by the end of Week Three. By Week Four the final script was completed and the sound outlined.

Additional team members were added as production need increased. For example, master lighting (overall environment) was started in the sets that were complete with shot lighting (character and shot concentration) following quickly. With a small production, only one set approved, and a very small team, the master and shot lighter were the same person; however as production proceeded an additional team member was added for lighting. By Week Five a very rough color script was completed and became a helpful general guide for remaining lighting and look development.

By Week Six a rough layout animatic was produced, cut together with storyboard drawings (shots that were not yet built). By Week Seven we were seeing animation and renders in the mix, with still some storyboards of a snowy landscape scene which proved to be difficult for the students, leaving one storyboard shot still in the pre-vis at week nine. By Week Ten the pre-vis showed that about half the shots were close to completion. As in any production, tasks were directed to the area that was in greatest need.

At this point, the team was reduced to a skeleton crew of five as many students would not be able to stay past end of quarter. This was not optimal during the final phase of production but had been planned for from the beginning due to the quarter schedule and render resource access. The team became more efficient as they gained insight into how a production works and how each task has an impact on other aspects. In addition, since quarter was no longer in session, the students were able to focus primarily on the project without juggling time management issues, except for a few of the students who also had other employment during the same time period. The animation short, despite the challenges, was completed on time.

The website redesign project took a back seat to the other projects during production due to limited resources. Wireframes were delivered and reviewed and content discussed which helped to move this project forward to the next phase, but would require more work. Finally bookmark and poster design were also difficult to manage given the shared resources. Despite these challenges, these projects' designs were successfully moved forward by juggling resources.

The results of this phase also proved highly successful - a fully rendered proof-of-concept 720p HD animation 1.5 minutes long, a website wireframe design, poster concepts and a lenticular bookmark design submitted for print.

2.3 Ongoing Collaboration

The success of the second phase propelled the continuation of this collaboration. The ongoing collaborations were organized in the form of small teams of interns working in Savannah. In the cases of the poster projects (Figure 9, Figure 10) and the clean room banner (Figure 10), the teams worked on site with the supervising professor and remotely with the Product Manager. On the website project, the students worked more closely with the Product Manager. In all these projects interns were selected based on their skill sets, but familiarity with the project from the pilot phase played an important role. Throughout the duration of the projects the interns were guided extensively both on the overall development process and on specific tasks.

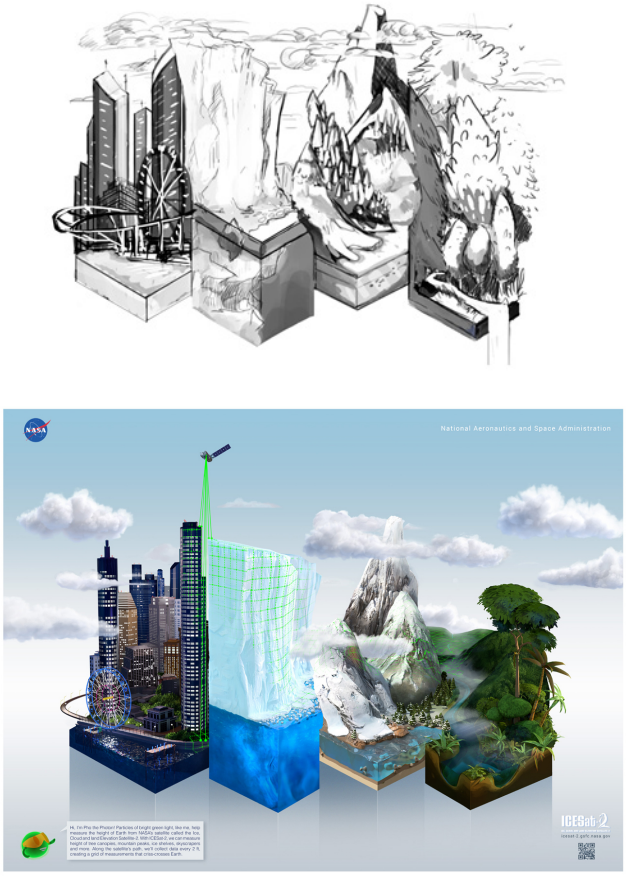


Figure 9: *Poster graphic illustrating biomes developed during a subsequent phase. Ideation phase (top) and produced version (bottom)*

3 Outcomes

The products of these collaborations so far are: 10,000 printed posters (two-sided) (Figure 9); 5,000 copies of single-sided posters; 5,000 copies of two-sided color bookmarks and 10,000 lenticular bookmarks (with 15,000 more to be printed soon); two mascots with character style sheets and resulting models; a 1.5 minute fully produced computer graphics 3D animation; a 10x15 ft banner (Figure 10) hanging inside the Engineering and Testing facilities complex at NASA/GSFC following NASA's highest level of clean room standards and two smaller pop-up banners; the complete design and media selection for the ICESat-2 website; the ideation and refinement of a digital pop-up book project; branding of the ATLAS project and design of products for team members internally. The products developed are disseminated freely to the public and schools all over the country through NASA public outreach events, ICESat-2's website and efforts from NASA's Earth Science Division. It should be mentioned that the products developed in these phases were just a small batch of projects and more might be coming down the line.

Both sides gained a better understanding of the challenges of such an initiative, the resources, and roles required of supervisors at SCAD and ICESat-2.

The resulting 22 internships and the knowledge and experience gained by the students are extremely valuable. The growth of the students working alongside a real-world partner in a production environment is precisely what SCAD's Collaborative Learning Center was designed to do - to enhance the student experience.

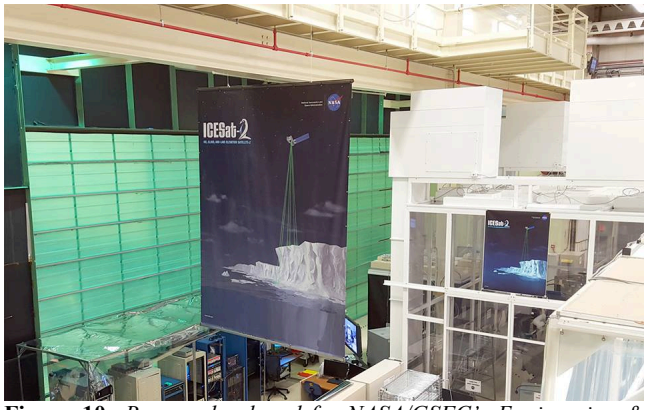


Figure 10: *Banner developed for NASA/GSFC's Engineering & Testing facilities.*

4 Observations

One of the biggest challenges of this endeavor was to determine how to develop and implement this unique platform/bridge between academia and government. Since none of the existing platforms (NASA summer internships, existing specialized course from academic institutions) sufficed, a new platform had to be designed that would work for both parties. As part of this effort, a variety of issues were identified and resolved, including copyright and legal issues, custom student internships, scope of work, period of performance, and deliverables for each student at each phase. Setting up the overarching platform and identifying the characteristics of the mechanism that would satisfy the needs of both partners required perseverance, solid understanding of the uniqueness of each party but most importantly a strong desire from both sides to collaborate in this project. Setting up the project, the platform, and the mechanics was challenging but it was evident that the partners were committed to do their best in fulfilling their promise and believing in each other. It soon became obvious that the platform would require a dynamic model in all aspects: duration of phases, scale and complexity of tasks, number of students involved, and resources required.

Crucial factors for the success of the project were the rapid turnaround by the art school in custom course design and the existence of the Collaborative Learning Center that provided legal and logistical support for the pilot phase.

The roles of the students were dominantly task-oriented according to their selected major and ability. There are many traits that make up an ideal candidate for pre-production and for production work. Most importantly the students who had the greatest impact on the project were the ones who were creative problem-solvers that balanced perfecting work with getting the job complete, possessed strong communication skills, were aware of how their part of the pipeline impacted the project and the deadlines of others, showed willingness to jump in when not working on their assigned task, were willing and able to follow feedback and accept criticism, showed work in progress, contributed without micromanagement, tested their results or assets and had the tenacity and energy to do all of the above throughout the span of the project.

During all phases, the role of the supervisors, both internal and external, was to provide guidance and encouragement while keeping the team on schedule. These supervisory roles often required careful analysis of the process and the ability to change directions quickly. Both internal and external supervision was extensive, and it might have been one of the key factors of success for this project. The effort from supervisors that was eventually required and provided was more than initially estimated. The backgrounds and prior experience in art science collaborations [Tsoupikova et al. 2013] of the Product Manager and the supervising professor might have influenced and enabled this project more than initially realized. The supervising professor had the prior experience and know-how of working in a full-production environment of a high-end animation studio and the Product Manager had served as an educator and adjunct professor in the past. Having these experiences allowed them to swap roles of educator/producer/product manager as required while working with the students during the various phases. The degree of granularity of supervision increased as production deadlines loomed. The leadership roles ranged from motivational and organizational oversight to acting as a safety net for avoiding disastrous decisions.

What is hoped is that the students have learned from these collaborations an appreciation for other disciplines both in and out of their field as well as for professional aspects of working. In particular the aspects of problem solving, follow-through, attention to detail and testing materials are of extreme importance in a collaborative production environment. The encouragement of using analytical skills to process feedback, communicate with a client and show initiative were skills they will take with them in their careers.

During these projects, a number of challenges were faced, some unique to each phase.

- During the pilot phase, some students were very uncomfortable with the freedom to create fresh new ideas or to change quickly while others thrived. Comfort level did not correlate with their chosen majors.
- During the production phase, helping students understand production and all that is involved in a production pipeline was important. Adherence to deadlines as well as educating students in how this affects others in a production was one of the greatest challenges.
- Students' understanding of the protocol and process in dealing with clients. A professional is accustomed to the hierarchy that exists in a production with levels of approval required for even seemingly small aspects. However, this concept is often new to the students, many of whom have not experienced production and are used to the final decisions for a project being made by either themselves or their professor.
- Changes in team size during production required careful and dynamic planning.
- Student availability also plays a role in a project that spans multiple quarters. It is not always possible to have continuity with team players as students graduate or have other academic commitments. We were fortunate to have several members who provided continuity.
- Collaborative efforts such as this require some remote communication which can at times create challenges or

impede progress. Communication is key to collaboration and adding distance to that communication adds some challenge, certainly not insurmountable but worth noting.

- Some team members participating in multiple projects became a time-management challenge and resource issue.

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Appendix

Collaborative Innovation Minor, Department of Art, Art History and Design, University of Notre Dame: https://artdept.nd.edu/undergraduate-programs/collaborative-innovation/

Conceptual Image Laboratory (CiLab), NASA/GSFC: http://cilab.gsfc.nasa.gov/

Entertainment Technology Center (ETC) Project Sponsors, Carnegie Mellon: http://www.etc.cmu.edu/work/project-sponsors/

Innovation Center, University of Illinois at Chicago (UIC): http://innovationcenter.uic.edu/

Innovation Space, Arizona State University: https://universitydesign.asu.edu/db/innovationspace-solutions-to-real-problems-through-product-design

Maryland Institute College of Art (MICA): https://www.mica.edu/

Master's in Human-Computer Interaction Capstone Project, Carnegie Mellon: https://www.hcii.cmu.edu/academics/mhci/capstone-project

NASA ICESat-2 mission: http://icesat-2.gsfc.nasa.gov/

NASA ICESat-2 Student Collaborative Project: http://icesat-2.gsfc.nasa.gov/fun_zone/collaborative_project/

Savannah College of Art and Design (SCAD): https://www.scad.edu/

NASA Interns, Fellows & Scholars OSSI: https://intern.nasa.gov/ossi/

NASA Pathways Programs: http://nasajobs.nasa.gov/studentopps/default.htm

SCAD Collaborative Learning Center (CLC): http://www.scad.edu/about/industry-partnerships

Scientific Visualization Studio (SVS), NASA/GSFC: http://svs.gsfc.nasa.gov/